

REMARKS/ARGUMENTS

Favorable reconsideration of this application is requested.

Claims 4, 6-11 and 13-20 are in the case.

Claims 4, 6, 7, 12 and 13 stand rejected under 35 U.S.C. § 103(a) as being unpatentable over Matsumoto et al. in view of Felts et al., Ogawa et al. and Saiki.

Claim 5 stands rejected under 35 U.S.C. § 103(a) as being unpatentable over these same references further in view of Cahalan et al.

Claims 8-11 stand rejected under 35 U.S.C. § 103(a) as being unpatentable over the same references as applied to Claims 4, 6, 7, 12 and 13, further in view of Komoto et al.

These rejections are traversed. Specifically, the invention relates to a method of manufacturing a gas barrier film having polypropylene as a base film, said method comprising:

a. activating carbon atoms of a surface of said polypropylene film by subjecting said polypropylene film to an argon plasma treatment, subsequently exposing the activated carbon atoms to air atmosphere to allow the activated carbon atoms to be bonded with oxygen, thereby introducing oxygen functional groups into the surface of said polypropylene film; then

b. reacting a silane agent coupling with the oxygen functional group of said polypropylene film, thereby bonding tuning molecular chains having, as a main skeleton, an -O-Si-O- structure, to carbon atoms of the surface of said polypropylene film through said oxygen functional group (-O-); and

c. plasma polymerizing the resulting product in a plasma atmosphere with an organic silane compound and oxygen, thereby forming a SiO<sub>x</sub> thin film on the surface of said polypropylene film having said tuning molecular chains bonded therein.

Such method makes it possible to prevent cracks from occurring in a  $\text{SiO}_x$  thin film while it is being formed, thus providing for the polypropylene film having excellent gas barrier properties. Since a tuning molecular chains having, as a main skeleton, an -O-Si-O- structure that has been bonded to the carbon atoms of the surface of the PP film is interposed at an interface between the PP film and the  $\text{SiO}_x$  thin film, a difference in mechanical property such as thermal expansion coefficient between the PP film and the  $\text{SiO}_x$  thin film can be alleviated. As a result, it is possible to inhibit or prevent the  $\text{SiO}_x$  thin film from being cracked due to such a difference in mechanical property between these films.

Additionally, due to the presence of the tuning molecular chains, the  $\text{SiO}_x$  thin film is closely adheres to the PP film. The  $\text{SiO}_x$  thin film is not only strongly adheres to the PP film, but also adheres to the PP film without generating a void where oxygen can pass through at the interface between the PP film and the  $\text{SiO}_x$  thin film. Therefore, it is possible to modify the  $\text{SiO}_x$  thin film portion at the interface of the PP film, and at the same time, to minimize the mobility of a gas, such as oxygen, at this interface portion.

These unobviously superior results obtained by the practice of the claimed invention are so shown by the examples and comparative examples in the case. Note the results set forth in Table 1 at page 26 of the specification, reproduced below.

Table 1

	Base film	Plasma + Silane Coupling treatments	Deposited SiO <sub>x</sub> film (thickness: 100 nm)	Oxygen transmission velocity (cm <sup>3</sup> /m <sup>2</sup> -24h-atm)
Reference Example 1	OPP	NONE	NONE	>2000
Comparative Example 1	OPP	NONE	YES	>2000
Example 1	OPP	YES	YES	37
Example 2	OPP	YES	YES	52
Reference Example 2	PET	NONES	YES	0.1
Reference Example 3	K-coat film			55

As is evident from Table 1, the gas barrier film of Comparative Example 1 wherein the  $\text{SiO}_x$  thin film was directly deposited on the OPP film without the argon plasma treatment, the silane coupling reaction was found to exhibit almost the same degree of oxygen gas transmission velocity as that of the OPP film per se (Reference Example 1), thus failing to take advantage of the inherent excellent oxygen barrier property of the  $\text{SiO}_x$  thin film.

In contrast thereto, the gas barrier films of Examples 1 and 2 wherein the  $\text{SiO}_x$  thin film was deposited on the OPP film after subjecting it to the argon plasma treatment and silane coupling reaction were found to exhibit excellent oxygen gas transmission velocity, i.e.  $37 \text{ cm}^3/\text{m}^2\text{-24h-atom}$  and  $52 \text{ cm}^3/\text{m}^2\text{-24h-atom}$ , respectively, which values were as low as about 1/60 of the gas barrier film of Reference Example 2 where the  $\text{SiO}_x$  thin film was deposited directly on the PET film, the gas barrier films of Examples 1 and 2 were almost comparable in gas barrier property to the K-coat film (Reference Example 3).

As so recognized by the Examiner, Matsumoto et al., the primary reference, fails to teach the required specifically defined steps of the inventive method. The reference merely discloses a film of, *inter alia*, polypropylene having a silicon oxide layer thereon. Such silicon oxide layer is formed by a pretreatment of the surface of the plastic layer, such as a discharge treatment with a silane coupling agent. No plasma treatment is effected in Matsumoto et al., the silicon oxide thin layer thus being attached directly to the substrate film, not through bonding tuning molecular chains. Significantly inferior results thus are obtained thereby, as shown by the comparative evidence in the case.

Felts et al., relied upon by the Examiner to cure these basic deficiencies of Matsumoto et al., in its plasma treating apparatus, however, discloses the use of oxygen as a necessary and required medium. This reference does not disclose or suggest the use of an argon plasma treatment, as particularly called for by the present claims. As so disclosed at page 9, lines 2-9

of the specification, when using an oxygen atmosphere in the plasma treatment, such can lead to greatly damaging the surface of the polypropylene film, thereby deteriorating the inherent properties of the polypropylene film. The use of an argon atmosphere, on the other hand, prevents such an occurrence. Felts et al. thus clearly teaches away from Applicants' discovery, oxygen being a required and necessary atmosphere.

The Examiner recognizes this deficiency and thus additionally relies on Cahalan et al. Cahalan et al., however, only discloses (col. 5, lines 62-68):

For plasma treatments in accordance with the present invention, sufficient oxygen may remain in the vacuum chamber after pumpdown to achieve the desired oxygen content even if an inert gas is used to generate the plasma or the exposure of the plasma treated substrate to atmospheric oxygen will be sufficient to provide the desired oxygen content.

Such teaching, however, manifestly does not remedy the inadequacy of Felts et al. Even in Cahalan et al. oxygen is required, an argon atmosphere, by itself, not being effective. Further, also note that in Felts et al. an oxygen atmosphere is required.

Saiki et al. is not concerned with a polypropylene film. It merely discloses a polyamide film having adhered thereto a silicon oxide layer. Such clearly does not teach, nor make obvious, the herein specifically defined steps for making a different gas barrier film having superior properties and characteristics.

Ogawa et al. teaches an antistatic film comprising a chemically adsorbed film of straight chain molecules each containing a conductive group and provided on a chargeable substrate via covalent bonds each containing a Si group. The making of such an antistatic film clearly is not comparable to the preparation of a gas barrier film by the particularly defined claimed steps. Here again, an oxygen plasma treatment is involved, not a plasma treatment in an argon atmosphere, as claimed.

Further, particularly with regard to Claim 7, unobviously superior results are achieved to the limitations as claimed therein. If the atomic ratio  $Q_O/Q_C$  is less than 0.05, it may

become difficult, due to an insufficient introduction quantity of the tuning molecular chains, to effectively utilize the tuning molecular chains as a buffering material for the PP film as well as for the  $\text{SiO}_x$  thin film, and to sufficiently enhance the bonding strength of the  $\text{SiO}_x$  thin film to the PP film. On the other hand, if the atomic ratio  $Q_O/Q_C$  is more than 0.20, the inherent properties (such as tensile strength) of the PP film may deteriorate due to an excessive introduction quantity of the tuning molecular chain. Such also refutes any possible presumption of obviousness of Applicants' discovery.

Komoto et al., additionally relied upon in the rejection of Claims 8-11, relates to chemically bonding silica sol to an organic resin, a completely different and nonanalogous method. It manifestly does not cure the basic deficiencies of the other references, for reasons as pointed out above, it being unrelated thereto and does not make obvious the additional claimed features of these claims.

Accordingly, withdrawal of the rejection of the claims under 35 U.S.C. § 103 is requested.


It is submitted that this application is now in condition for allowance and which is solicited.

Respectfully submitted,

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